PACIFIC AIRMOTIVE CORPORATION

PAC

Municipal Airport, Millville, New Jersey 08332 609/825-6000

May 9, 1986

jmw 5/12

Mr. Joshua M. Workman
Senior Water Resource Control Engineer
California Regional Water Quality Control Board
Los Angeles Region
107 South Broadway
Suite 4027
Los Angeles, CA 90012-4596

Dear Mr. Workman:

SUBJECT: PAC - Fuel Spill Emergency Clean Up

In accordance with your letter dated March 14, 1986 and our interest in finalizing the subject project, we requested Kennedy/Jenks/Chilton, Consulting Engineers, to provide a plan for installing a vadose zone monitoring system. This system should detect migration or potential migration of residual jet fuel remaining from our emergency clean up actions completed in July 1985. The report presenting their recommendations is attached for your perusal.

From the onset, it was the intention of PAC & Kennedy/Jenks/Chilton to remove the majority of the released jet fuel and replace contaminated soil with new, compacted soil. To this end, contaminated soil was removed to a depth of 30 feet, and replaced by clean, compacted fill. To preclude migration due to percolation of any possible remaining residue, the area was then covered with an asphaltic concrete cap. This cap completely covered the excavation and abutted the adjacent structure and covers the area where the leakage occurred.

We continue to support the Board's efforts to ensure ground water protection should a potential hazard exist. However, as noted in Kennedy/Jenks/Chilton's report dated January 9, 1986, groundwater lies 108 feet below the depth at which further migration was conservatively estimated to occur.

Considering their experience in this field, their previous submissions and the attached report, we would suggest no further action is needed and, therefore, request the Board to permit Pacific Airmotive Corporation to consider the project complete.

Sincerely,

Christopher M. Andrews

Christopher M. Andrews
Vice President - Operations

DAVID A. BACHAROWSKI

MAY 16 1986

lf
attachment
cc: J. Bales/B. Wettstein

Kennedy/Jenks/Chilton
Consulting Engineers
657 Howard Street
San Francisco, California 94105
415-362-6065

7 May 1986

Mr. Christopher M. Andrews
Vice President - Engineering Quality
Control and Facilities
Airwork Corporation
Millville, New Jersey 08332

Subject: Pacific Airmotive Corporation - Burbank, California
Survey of Vadose Zone Monitoring Systems
(K/J/C 4101-B-00)

Dear Mr. Andrews:

In conformance with your request of 14 April 1986, we have prepared a report summarizing our survey of commercially available vadose zone monitoring systems capable of detecting liquid phase hydrocarbons (and specifically, jet fuel) in unsaturated soil. This survey was conducted in order to select a monitoring system that would meet the objectives presented in the Los Angeles Regional Water Quality Control Board (RWQCB) letter dated 14 March 1986. The RWQCB requested in that letter that a monitoring system be installed to confirm that the jet fuel remaining in soil at residual concentrations is not migrating downwards to a significant degree.

In conducting our survey, equipment vendors were contacted over the telephone and asked 1) if their system could meet the specific requirements of the desired monitoring program and 2) to provide examples of installation where their system has been used for similar monitoring purposes. Meetings with selected vendors of the more promising monitoring systems were then conducted in our office for more detailed discussions and equipment demonstrations. As explained in detail below, based on our discussions with equipment vendors, a monitoring system providing reliable and accurate detection of vertically migrating liquid phase hydrocarbon (jet fuel) is <u>not</u> commercially available at this time.

INTRODUCTION

There are numerous vadose zone monitoring systems currently available from equipment vendors. Most of these systems were developed for two applications. The first application is for initial detection of solvent or hydrocarbons in soils resulting from leaks from underground storage tanks, or for hydrocarbon liquids or vapor in the annular spaces of double walled tanks due to the rupture of the primary contaminant tank wall. As such, these methods were designed to trigger alarms rather than provide quantitative information indicating the concentration levels of vapor or liquids present. The second application of vadose monitoring devices is to sample interstitial liquids in the soil matrix; a tool originally developed for irrigation research. Inquiries to vendors supplying both categories of systems identified no known application of this technology for the monitoring objectives desired by the RWQCB. Therefore, any application of these methods must be viewed as experimental and highly site-chemical specific, since sampling depth, soil formations, and target chemicals limit the reliability of many of the available systems to provide accurate information.

For the purpose of this evaluation, monitoring systems have been grouped into two categories: direct measurement and indirect measurement. Direct measurement implies that a physical sample of either soil, interstitial liquid, or vapor can be collected from a particular soil zone and brought to the laboratory for analysis. Indirect measurement depends upon either interpretation of non-quantitative data, quantitative data which cannot be verified as representing specific soil zones, or data inferring changes in the hydrocarbon content in pore spaces in the soil based on secondary physical parameter responses (e.g. changes in electrical properties). Available devices in each category are discussed below.

DIRECT MEASUREMENT METHODS

The direct measurement methods that were evaluated included (1) soil sample collection with soil borings, and (2) sampling liquid phase hydrocarbon (or moisture) contained in interstitial soil voids with the aid of lysimeters.

Soil Borings

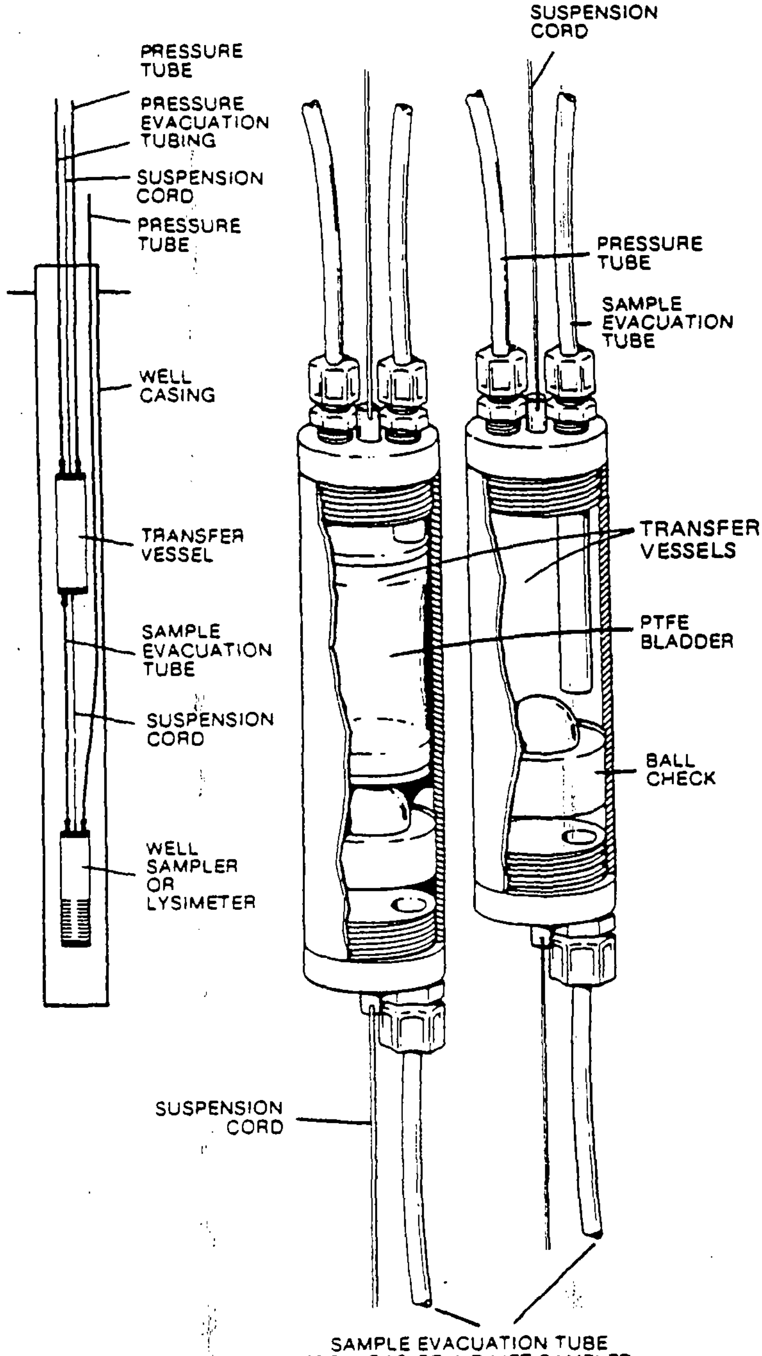
Collecting undisturbed soil samples from soil borings drilled by hollow stem auger techniques and analyzing the samples in the laboratory for hydrocarbon content is the most direct method for determining if jet fuel is migrating to a particular zone. Laboratory analysis is not only quantitative but can provide hydrocarbon fingerprints for comparison with a PAC jet fuel sample to confirm the hydrocarbon source. However, sampling is not repeatable without further drilling expense for each future sampling event. There are significant mobilization, drilling, laboratory and residue disposal costs.

Lysimeter with Permanent Transfer Vessels

Two types of lysimeters are available. The first type relies on a transfer vessel permanently installed in a soil boring containing the lysimeter used to store the liquid sample until eventual recovery of the sample to the surface (see Figure 1). In the second system, a messenger transfer vessel is lowered down the boring in which the permanent lysimeter is installed. The transfer vessel is then retrieved with the sample inside (see Figure 1).

Both categories of lysimeters rely on similar devices for the collection of liquid samples from soil surrounding the lysimeter. Porous ceramic or teflon collection "cups" are installed in a drilled boring, and a vacuum applied to the collection cup is utilized to obtain a sample of liquid present in saturated or unsaturated soils. Although they are most effectively utilized when the soil moisture content approaches saturation levels, they have been applied in unsaturated zone soils.

In order to efficiently draw the interstitial liquid into the porous cup, a soil suction gradient towards the lysimeter from the native soil must exist. This is usually achieved by placing the lysimeter cup in fine grained material, such as silica flour, which would provide a higher capillary suction than the coarser native soil. Pore liquid in the native soil would be drawn by capillary action into the fine fill, whereupon the vacuum applied to the lysimeter cup would draw the liquid into the lysimeter. Although not a common application, vendors indicate that the lysimeter cup material should be permeable to hydrocarbons; however, the lower surface tension of hydrocarbon (21.8 dynes/cm for an octane-vapor system at 20°C compared to 72.8 dynes/cm for a water-air system) may reduce the soil suction gradient, thereby reducing the volume of liquid drawn into the fill material. This would probably significantly prolong the sampling time during which a vacuum must be maintained to obtain an adequate sample volume (at minimum approximately 40 ml for chemical analysis with a detection limit of 1 ppm).



(From TIMCO ™)

Kennedy/Jenks/Chilton

Pacific Airmotive Corporation
Burbank, CA

Lysimeter with Permanent Transfer Vessel

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Figure 1

The two primary disadvantages of this system are (1) the method by which the vacuum is applied, and (2) the large volume of liquid that must be collected in the transfer vessel to assure recovery to the surface. A vacuum must be supplied from the vacuum source at the surface to the lysimeter placed at the anticipated depths of 90 feet or more. Therefore, all seals must be tight and tubing connections secured since a vacuum may have to be supplied for days due to the low saturation levels anticipated. Installing the lysimeter and vacuum lines to a depth of 90 feet may require repeated attempts until a vacuum-tight installation is completed.

Also, due to the great sampling depths, a high pressure would be required to lift the accumulated sample volume from the lysimeter cup to the surface. Since the expected pressure would probably force the liquid back through the cup into the fill material, a transfer vessel would be required. First, a low pressure system would raise the liquid into the transfer vessel. Then a high pressure system could be connected to the transfer vessel to bring the sample to the surface.

Although it is possible to connect multiple lysimeters to one transfer vessel, the installation difficulties associated with the depth required at the PAC site make it inadvisable to install more than one lysimeter in each boring. Because there is a relatively high rate of lysimeter failure reported by vendors even for conventional soil water applications, several individual borings equipped with a lysimeter in each boring, would be recommended, thus adding significantly to the project cost.

The major drawback to this system is that it is likely that only a limited volume of liquid will be collected in a given lysimeter. A certain volume of liquid will be lost due to coating or wetting the transfer vessel and 90 feet or more of recovery tubing. Therefore, there is a possibility that little, if any, liquid sample volume will be actually recovered at the surface.

<u>Lysimeter with Messenger Transfer Vessels</u>

These lysimeters differ from those previously discussed only by the type of transfer vessel employed. The introductory comments presented above on fill placement and effects of surface tension on soil suction gradients are relevant to this system as well as the previous one.

This lysimeter system differs from the permanent, downhole transfer vessel system in that a glass sampling tube (see Figure 2) which is under a negative pressure, is sent down the hole to provide a vacuum source to the permanently installed porous lysimeter cup. A rubber septum is mounted on the top of the lysimeter cup and provides access for withdrawing liquid samples.

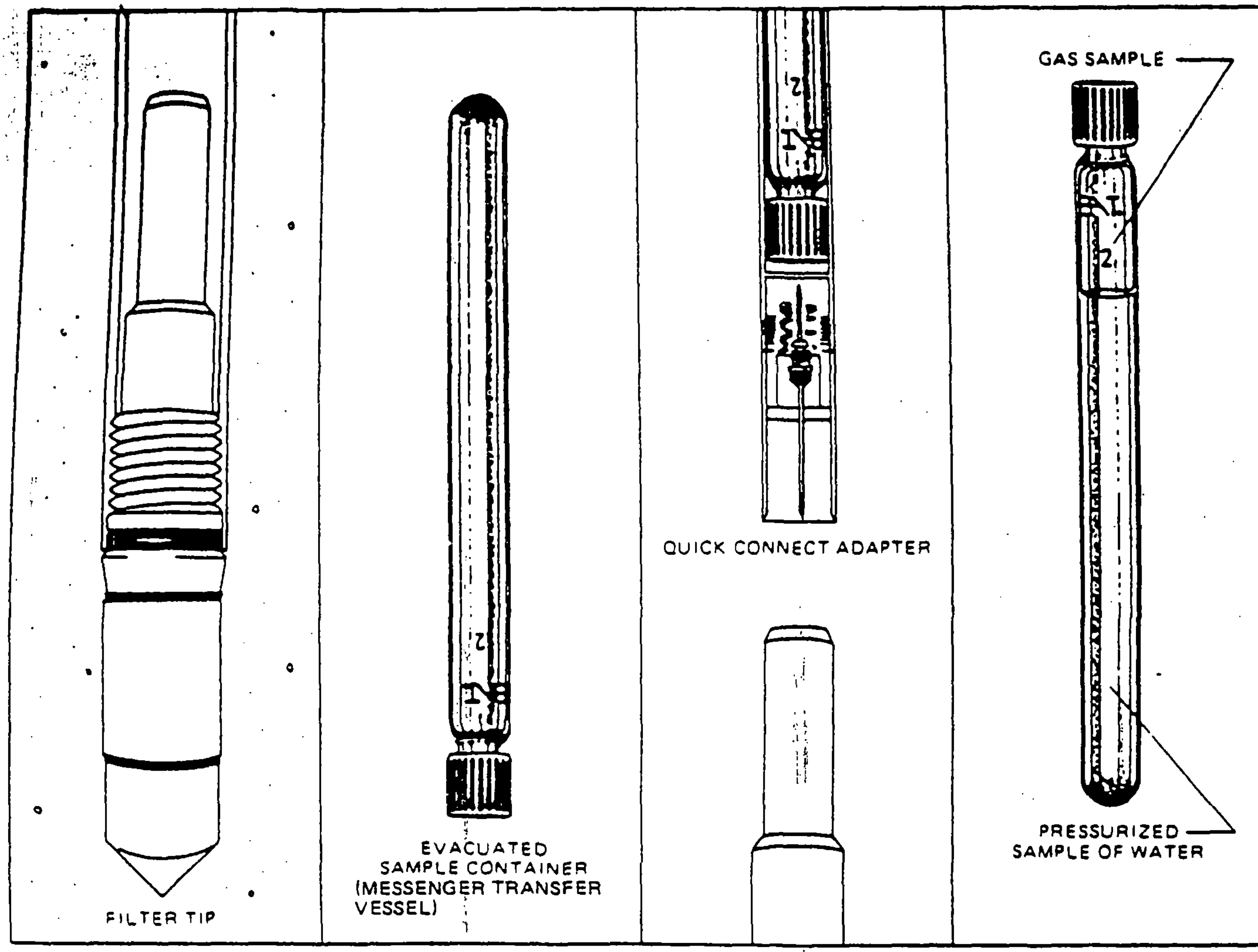
In order to collect a sample from the lysimeter cup, the evacuated glass tube is sent down the hole inside a larger sampling tube containing a double pointed syringe tip mounted ahead of the glass tube. The syringe must first penetrate the rubber septum on the porous cup, and then the septum on the glass sample tube, thereby applying a vacuum to the lysimeter cup.

The advantage of the messenger transfer vessel system is that small quantities of liquid can be collected and brought to the surface since great lengths of tubing are not required.

The disadvantages of this system are similar to those discussed above for lysimeters in general, i.e., the effect of hydrocarbons on soil suction gradients, proper lysimeter contact with fill material, and maintaining a prolonged vacuum. In addition, because of the great sampling depth, it is uncertain that the outer messenger tube holding the transfer vessel and syringe can be properly manipulated from the surface so that the syringe can repeatedly hit the target septum. Unless the syringe is tightly buried in the septum, it is unlikely that a prolonged vacuum can be maintained. As discussed above, the low saturation levels anticipated at the PAC site would require a prolonged sampling period during which time maintaining a sufficient vacuum by means of a syringe and septum would probably be difficult. If such difficulties occur, liquids that may be present in the soil may not be drawn into the lysimeter.

INDIRECT MEASUREMENT METHODS

A number of methods were initially considered for the PAC site. The more exotic methods such as neutron-gamma logging and soil moisture blocks were not considered feasible and are not presented in this report. The two types of systems discussed in detail below are (1) vapor detection systems, and (2) a cable system with electric wires coated with an insulation material that dissolves when in contact with hydrocarbons.



Soil fluids are drawn via a permanently installed filter tip into an evacuated, hygienically clean sample container. Fluid transfer is facilitated by a special quick-connecting adapter, yielding an encapsulated sample of pressurized gas and water. (From BAT®)

Kennedy/Jenks/Chilton

Pacific Airmotive Corporation
Burbank, CA

Lysimeter with Messenger Transfer Vessel

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Figure 2

Theoretically, vapor monitoring should be considered as a feasible alternative since migrating liquid phase hydrocarbons would produce detectable vapors. However, it is likely that vapors already exist in the soil below the soil zone containing liquid phase jet fuel either emanating from the jet fuel plume itself, from the anaerobic degradation of fuel hydrocarbons resulting in methane formation, or even from offsite hydrogen // sources. Therefore, interpretation of vapor concentration data would prove difficult.

As previously discussed based on available data, most of the current available vapor monitoring systems have been developed for the early detection of leaks and are designed to trigger alarm systems. Depending on the specific equipment, various degrees of system modifications would be required to provide accurate vapor concentration readings which could detect changes in vapor concentrations corresponding to fuel migration.

Active Vapor Sensing Devices

These systems require the installation of a casing with a screened section located in the zone to be sampled. The annular space surrounding the casing above the screened section must be effectively sealed to prevent vapors from penetrating the boring fill material and entering the well. Tubing is inserted in the well, and packing would be installed at the top of the screen to prevent surface air from entering the sampling section.

Active systems require that a stream of air drawn from the vapor well be passed over hydrocarbon sensors installed at remote locations at the surface. Although most of these aspirating systems have been designed to trigger an alarm condition indicating that a hydrocarbon leak has occurred, some systems can be modified to provide resistivity readings which could be calibrated to a specific hydrocarbon vapor concentration for each individual sensor.

Active vapor monitoring systems are not appropriate for the monitoring program objectives at PAC site for the following reasons. Vendors contacted by Kennedy/Jenks/Chilton have indicated that these systems are designed to run continuously, otherwise repeated instrument calibration is required and that even with intermittent operation, a startup period is necessary to equilibriate the sensor with the aspirated air stream. Experience has shown that vapors are drawn from considerable

then run cont...

distances by the aspirating air stream. It is likely that the vapors from the overlying soils containing residual jet fuel will be drawn in the well and detected by the monitors, providing a false indication of liquid fuel migration.

Isolate!

Concentration Related - [illegible] Gasoline 1st [illegible] monitor chg

Passive Vapor Sensing Devices

Passive vapor detection systems do not require air to flow over the downhole sensing unit. These devices generally measure the resistance between two filaments that varies with the hydrocarbon vapor concentration between the filaments. For intermittent system operation, the electrical sensor must be calibrated each time the system is energized.

While this device has a smaller detection radius than that of the aspirated air systems, it does not respond selectively to jet fuel hydrocarbons. Readings of increased hydrocarbon vapor concentrations may result from methane production during anaerobic degradation as well as increases in jet fuel constituent vapors, thereby creating a false impression of fuel migration. Also, it is unlikely that a stable reference reading could be obtained, whereby true changes in vapor concentrations could be identified.

Hydrocarbon Sensitive Cables

Hydrocarbon sensitive cable systems rely on measuring changes in voltage across wires in the cable that are attached to a terminal resistor. The detection portion of the cable is coated with an insulation material that readily dissolves in the presence of hydrocarbons. However, equipment vendors that were contacted indicated that even low concentration of hydrocarbon vapors could, with prolonged exposures, dissolve the wire insulation and trigger the detection response signal. Since hydrocarbon vapors are likely to be present in the zones being sampled for liquid phase hydrocarbons, there is a significant chance with the cable sensor system that hydrocarbon vapors rather than free liquid will trigger a detection responses. Once triggered, the cable system becomes useless for further monitoring.

CONCLUSIONS AND RECOMMENDATIONS

Based on our review of information supplied by equipment vendors of commercially available vadose zone monitoring systems, there are no systems that can reliably and accurately monitor the progressive vertical migration of liquid phase hydrocarbon once a leak has occurred, particularly at the required depths. As indicated in our summary presented in Table 1, the direct measurement methods are likely to miss detection of liquid hydrocarbons when present (false negative response), while the indirect measurement methods are likely to indicate that hydrocarbons are present, even though they are only responding to hydrocarbon vapors (false positive response). It is also uncertain that the vapors to which the indirect measurement devices would respond are actually jet fuel hydrocarbons or even from sources of jet fuel at the PAC site.

Because our review described herein has revealed no vadose zone monitoring systems that can provide conclusive detection of migrating liquid phase hydrocarbons, we cannot recommend installing a vadose zone monitoring system at the PAC site for the intended purpose of monitoring changes in residual jet fuel concentrations below an existing plume. Any such application would be experimental.

If you have any questions on this survey, please contact us.

Very truly yours,

KENNEDY/JENKS/CHILTON, INC.

Noel Lerner

Noel M. Lerner
Project Manager

Dean R Schnaible

Dean R. Schnaible
Senior Geologist

NML/DRS:pjv34

Attachment to Kennedy/Jenks/Chilton
letter report to Airwork Corporation
dated 7 May 1986

TABLE 1

SUMMARY OF COMMERCIALLY AVAILABLE VADOSE ZONE MONITORING SYSTEMS FOR HYDROCARBONS
(PACIFIC AIRMOTIVE CORPORATION - BURBANK, CALIFORNIA)

Method	Discrete Zone Sampling	Selective for Jet Fuel Constituents	Specialized Skills Required	Potential for Incorrect Data Interpretation	Known Applications
<u>Direct Measurement</u>					
Soil Borings	Yes	Yes	Drilling, sampling, and analytical laboratory	Low	Soil and groundwater investigations
Lysimeters					
Permanent Transfer Vessels	Yes	Yes	Installation - extremely difficult	High - Liquid hydrocarbons may be present but not sampled	Limited field use
Messenger Transfer Vessels	Yes	Yes	Installation and sampling - new technology	High - Liquid hydrocarbon may be present but not sampled	Limited field use
<u>Indirect Measurement</u>					
Active Vapor Sensors	No	No	Sealing annular space, equipment calibration	High - Vapor interference	Tank monitoring systems
Passive Vapor Sensors	Yes	No	Equipment calibration	High - Vapor interference	Tank monitoring systems
Hydrocarbon sensitive cables	Yes	No	Cable installation - new technology	High - Vapor interference	Tank monitoring systems